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Structure, growth, mortality and size at sexual maturity of various populations *Astacus leptodactylus* Eschscholtz, 1823 (Cructecea: Decopada) in Turkey.

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ABSTRACT

Population characteristics such as population structure, growth, mortality, and size at sexual maturity of the *Astacus leptodactylus* were examined in various lakes based on size-frequency distribution by using FISAT software program from April 2002 to March 2003 in Turkey. Specimens were collected monthly using with fyke-nets of 32 mm mesh size. Population size based on size-frequency distribution between female and male and between two years data were described. Males outnumbered females in all lakes and the average sex ratios (male/female) were found to be significantly different. Mean total length (TL mm) was found similar for male and female crayfish in all lakes. However, while the total length of the samples from Iznik was the largest (26-68.5 mm TL),the samples from Ulubat it was the smallest (15.2-82.3 TL), where as the population from Manyas Lake was intermediate (23 mm-71.5 mm TL). Growth parameter was estimated by using the modified von Bertalanffy growth function for male and female. Growth was continuous throughout the year. Female crayfish were larger and grew faster than males at the same age. In addition, total mortality based on the seasonalized length-converted catch curve for both sexes were Z= 1.87, (female), Z= 1.52, (male) in lake Manyas, Z= 1.78, (female), Z= 1.69, (male), in lake Ulubat; and Z= 1.79, (female), Z= 1.78, (male) in lake Iznik. Exploitation rate between female and male were calculated in lakes Manyas, Ulubat, and İznik as E= 0.57, (female), E= 0.54, (male) E= 0.63, (female), E= 0.57, (male) E= 0.66, (female), E= 0.53, (male), respectively.

Introduction

The only native crayfish species of Turkey, Astacus leptodactylus (Eschscholtz, 1823) lives in cold lakes, ponds, and rivers throughout the country. It is considered a valuable fishery resource, as there are no other commercially important species of Crustacea found in fresh waters of Turkey. A. leptodactylus was introduced into many countries, e.g., Poland, Italy, Germany, England, Spain, and France, where it escaped into the wild and has established large populations in many locations (Köksal, 1988; Holdich and Reeve, 1991; Harlıoğlu and Türkgülü, 2000; Harlıoğlu and Holdich, 2001). In Turkey, A. leptodactylus occurs naturally in the lakes Eğirdir, Beyşehir, Akşehir, Eber, Civril, Apolyont, and Manyas (Erençin and Köksal, 1977).

Until 1984, freshwater crayfish had an important role as an export product, but after 1986 crayfish production declined dramatically in most lakes and dam reservoirs from 5000 tonnes to 200 tonnes, because of the crayfish plague, Aphanomyces astaci Schikora, 1903, and through, pollution, overfishing, and agricultural irrigation (Bolat, 2001). There has been an increase in the amount of A. leptodactylus in the wild catch in recent years (Bolat, 2001). Total crayfish harvested in Turkey was about 2317 tonnes in 2004 (Harlıoğlu, 2008).

Growth in crustaceans is very difficult to estimate, since exoskeletons are lost during moulting and thus cannot serve as an index of the age of an individual. Consequently analysis of length-frequency data (LFD) has been widely used to identify year classes. Von Bertalanffy growth functions (VBGF) B (Ricker, 1975) are generally fitted to the mean length at estimated age of a year class (Frechette and Parsons, 1983; Roa and Ernst, 1996; Tuck et al., 1997).

According to the Turkish Fishery Regulations, the minimum landing size for *A. leptodactylus* is 10 cm total length. In addition, catching period of *A. leptodactylus* is regulated by the government. Fishing starts on the 15 th of June and ends on the 24 th of December (Anonymous, 2002). On the other hand, fishing activities had been banned for a decade when the sampling for this study was conducted. When the banned fishing was released fishing potential increased gradually each season. Although *A. leptodactylus* harvesting was forbidden between 1987 and 1999 in all Turkish lakes due to plague (Bolat, 2001), the catch of crayfish extended to 2002 in Manyas lake (Anonymous, 2002). Knowledge of the impact of present management practices on recruitment, growth, mortality and yield of primary and secondary waves of recruitment of *A. leptodactylus* under fishing exploitation is needed.

The purpose of this study was to describe the population characteristics of *A. leptodactylus* under fishing exploitation. Specific objectives were as follows: (1) to monitor rates of growth, mortality and contribution to yield of each identifiable of *A. leptodactylus*. (2) to describe the temporal changes in the fishing pressure.

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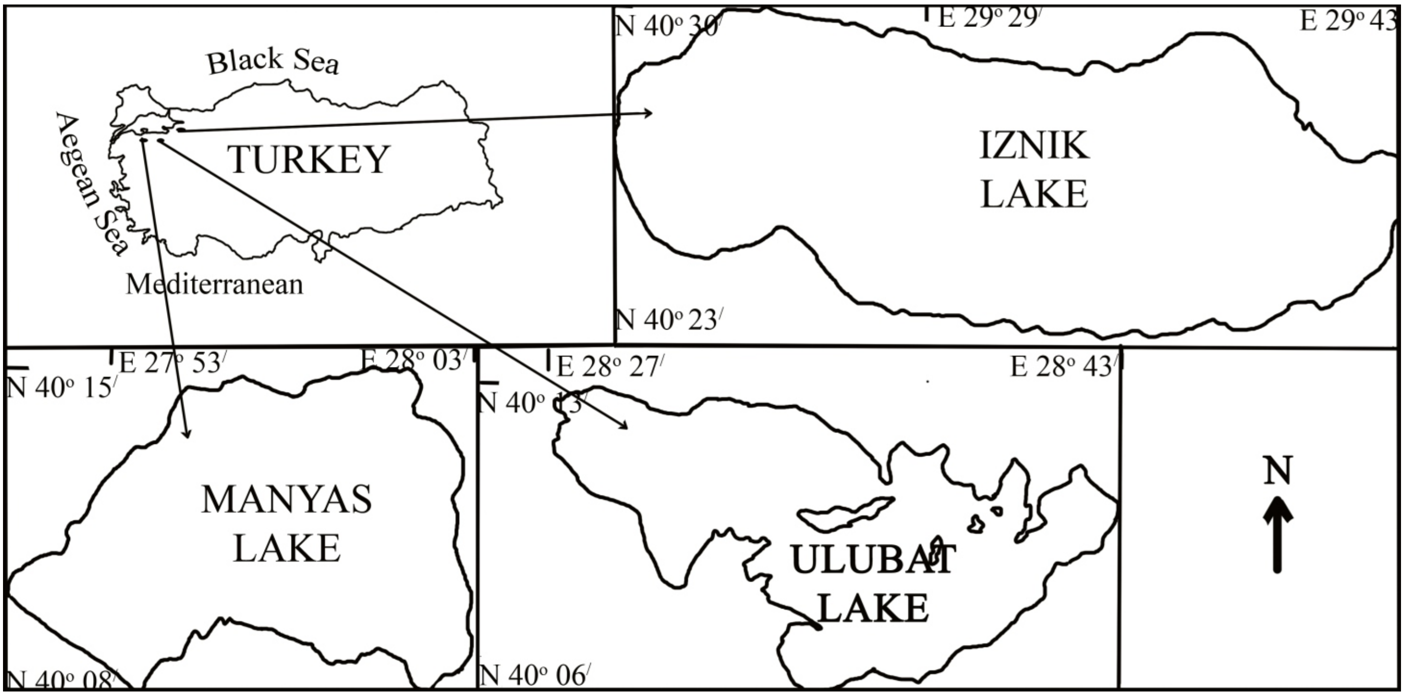

Figure 1. Fishing Lakes in Turkey

Material and Methods

Study area

Three different lakes, Apolyont, Iznik, and Manyas, were chosen as study sites from April 2002 to March 2003 (Figure 1). Apolyont Lake is 2400 ha with an average depth of 2.5 m. of its 21 fish species, *Esox lucius* Linnaeus, 1758, *Cyprinus carpio* Linnaeus, 1758, *Carassius carassius* (Linnaeus, 1758), and *Scardinius erythrophthalmus* (Linnaeus, 1758) are the economically important ones (Geldiay and Balık, 1999). The surface area of Iznik Lake is 3080 ha and the average depth is 30 m. This lake is inhabited by 14 species of fish, including, *Cyprinus carpio*, *Silurus glanis* Linnaeus, 1758, *Atherina boyeri* Risso, 1810, and *Rutilus frisii* (Nordmann,1840), which are economically important species (Colak, 1994). The surface area of Manyas Lake is 3169 ha and its average depth is 3 m. This lake harbours 24 fish species, and four of these, *Esox lucius, Cyprinus carpio, Silurus glanis* and *Caspialosa maeotica* (Grimm, 1901) are economically important ones (Turan et al., 2005).

Population sampling

A regular sampling program was established to survey crayfish fecundity in three different lakes in Turkey. Crayfish were sampled monthly using fyke nets of 34 mm mesh size from April 2002 until March 2003. Ten nets with frozen goldfish, *Carassius auratus* (Linnaeus, 1758) were set randomly along the shoreline at intervals of approximately 10 m, and at between 2 and 3 m depth for each sampling session. The nets were set in the late afternoon and were visited early the following morning, because *A. leptodactylus* is active at night and often hides in a shelter during the day (Bolat, 2001).

Size Measurement

In the study, a total of 3568 samples were collected. The samples were preserved in 4% formaldehyde for a day and then transferred to 70% ethanol for storage. Sex discrimination was performed by inspection of the first and second pairs of pleopods. The total length (TL) of crayfish from the apex of the rostrum to the caudal margin of telson and carapace length (CL) from the posterior margin of the orbit to the mid-dorsal posterior margin of the carapace were measured with a vernier caliper and were used as basis for the size of crayfish.

Population analyses

Cohort identification was conducted by using the Bhattacharya (1967) method by FISAT-II (FAO-ICLARM Fish Stock Assessment Tools) on 3mm size-frequency histograms. This method serves to estimate mean size of individuals in each cohort. For the estimation of growth parameters, length-frequency distribution (LFD) was analyzed by the program (Gayanilo et al., 1995). The program generated data on growth increments that were analyzed according to von-Bertalanffy growth functions parameters; K is the growth rate at which the maximum size, L_∞, is approached. The best curve was chosen on the basis of this index using the L_∞, K, and the LFD of the pooled data from the whole study period with ELEFAN I. The other parameter was computed (t_0) by the empirical equation for growth fitting (Froese and Binahlan, 2003).

$$Log(-t_0)=-0.3922-0.2752 \times \log L_\infty -1.038 \times \log K \quad (1)$$

Instantaneous rates of total mortality (Z) were estimated by length-converted catch curves (Pauly, 1980); ln (N/(dt)= a + bt where the slope of regression (b) is the estimate of Z; N is the number of individuals in a given length class; dt is the time taken for the individuals growth through the length class; and t is the mean age of individuals in that class.

Total instantaneous mortality coefficient (M) was estimated by using empirical model of Pauly (1990);

$$\ln M=-0.0066-0.279\ln L_\infty+0.6543\ln K +0.463 \ln T \quad (2)$$

where *T* is the mean water temperature in degrees centigrade (16°C annual). Fishing mortality (F) was calculated by the difference between total (Z) and natural (M) mortality: Z=M + F. The exploitation rate (E) was calculated by the quotient between fishing and total mortality: E=F/Z (Sparre and Venema, 1997).

Results

Environmental variables

Water quality and temperature were monitored throughout the study. The mean temperature and dissolved oxygen did not differ among the lakes; however, pH, water conductivity, calcium content,

Table 1. Mean carapace lengths and their standard error for *A. leptodactylus* by females and males in three lakes.

	Fishing Lakes		
	Iznik	Ulubat	Manyas
Female	44.43 ±4.32	43.16 ± 9.08	44.22 ± 7.1
	(31.70–69.60)	(15.15–67.55 mm)	(28.40–70.95 mm)
Male	43.24 ± 6.1	44.68 ± 5.14	41.67 ± 5.38
	(23.30–44.68)	(26.4-66 mm)	(23.9–73.7 mm)

magnesium content, and hardness were found to be significantly different. The lowest values for dissolved oxygen and pH were observed at the morning reading (0800 h) and the highest values in the evening (1800 h). Water temperature ranged from 5.9 to 32.2°C over the total sampling period. Calcium concentration was the lowest in Lake Iznik (33.8 mg/L), whereas it was the same in the lakes Ulubat (52.10 mg/L) and Manyas (54.2 mg/L). Magnesium content was the lowest in Manyas (34.8 mg/L), while in Iznik Lake (76.1 mg/L) it was the highest.

Population structure

In total, 3568 *A. leptodactylus* individuals (males= 2115 and females= 1453) were examined by carapace length (CL) measurement with sizes ranging from 15.15 mm to 73.7 mm CL between April 2002 and March 2003. Mean carapace length (CL± SD) of the sample is summarized for female and male in various lakes (Table 1).

Mean total length (CL mm) was statistically similar for male and female crayfish in all the lakes. However, the total length of the samples from Iznik was the largest (26-68.5 mm CL), and from Ulubat it was the smallest (15.2-82.3 CL), while the population from Manyas Lake was intermediate in this respect (23mm-71.5mm TL) (Table 2). Monthly sampling indicated that the proportion of males caught tended to increase until April 2002. A decline began in late May 2002 to continue until March 2003, with the exception of December 2003. In contrast, the percentage of males caught in the lakes Iznik and Manyas indicated the same pattern (for monthly sampling), and high amount

Table 2. Mean carapace lengths and their standard error for A. leptodactylus by females and males in three lakes.

	Manyas Lake		Ulubat Lake		İznik Lake	
	Female	Male	Female	Male	Female	Male
L_∞	*73.45*	*81.9*	*74.96*	*76.81*	*71.47*	*69.97*
K	*0.61*	*0.55*	*0.46*	*0.51*	*0.41*	*0.68*
SS	12	12	12	12	12	12
SL	70.5	79.5	73.5	76.5	70.5	69
Rn	0.34	0.25	0.23	0.29	0.34	0.24
t_0	*-0.212*	*-0.23*	*-0.286*	*-0.254*	*-0.329*	*-0.191*
Z	1.87	1.52	1.78	1.69	1.79	1.78
F	1.06	0.82	1.13	0.91	1.19	0.03
M	0.81	0.7	0.65	0.68	0.6	0.85
E	0.57	0.54	0.63	0.57	0.66	0.53

of crayfish were caught in December 2002 and January 2003. The result indicates that males in the samples were more than females.

Sex ratio was determined separately for each lake, and males outnumbered females in all lakes. The average sex ratios (male/female) were found to be approximately 1.00/0.68 in Ulubat Lake, which had 59.5 % male and 40.5 % female which was a significant difference (P<0.05). The samples from the Iznik Lake included 67.8 % male and 32.2 % female. These percentage values were also found significantly different (P<0.05) and sex ratio (male/female) was 1.00/0.47. Manyas Lake sheltered 65.4 % male and 34.5 % female. There was a significant difference between both sexes in percentage (P<0.05). In total population, sex ratio (male/female) was found to be 1.00/0.53.

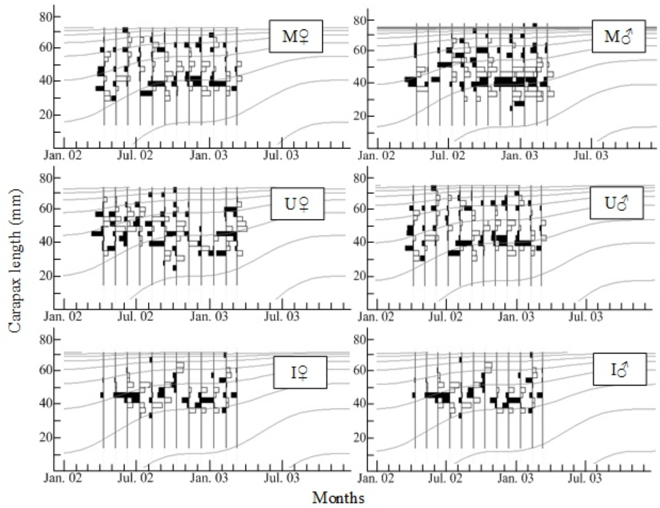

Figure 2. Seasonalized von Bertalanffy growth curves of *Astacus leptodactylus* on the restructured length-frequency histogram.

Length-frequency distribution and growth

Model progression of 3 mm size classes over harvesting season, as used in the ELEFAN program, is given in Figure 2. The best fits to the length frequency data (LFD) identified a distinct a new cohort, which becomes appearances around July in all lakes. The age groups and their abundance showed that the increments between consecutive groups generally decreased in both sexes of crayfish (Table 2). Male crayfish had more recruitment groups than females in this study. The separation indices (S.I) which were different for the lakes, represented better in the summer months for both sexes as these included more recruitment groups. The practice of FISAT indicated that lengths of females ranged from approximately 32 mm (in Winter) to 62 mm (in Summer), with satisfactory S.I. (Table 3).

The growth pattern, which was seasonalized von Bertalanffy growth curves, of *A. leptodactylus* is shown in Figure 2. Parameters of the von Bertalanffy growth equation L_∞, K, and t_o were indicated by ELEFAN for each sex and for various lakes in (Table 4). The values were estimated in lakes Manyas, Ulubat, and İznik as L_∞= 73.45, K= 0.61, (female), L_∞= 81.9, K= 0.55, (male), L_∞= 74.96, K= 0.46, (female), L_∞= 76.81, K= 0.51, (male), and L_∞= 71.47, K= 0.41, (female), L_∞= 69.97, K= 0.68, (male), respectively. t_o, the other parameter of the von Bertalanffy growth equation, was calculated for both sexes in lakes Manyas, Ulubat, and İznik as -0.212, (female), -0.230, (male), -0.286, (female), -0.254, (male), and -0.329, (female), -0.191, (male), respectively.

Mortalities estimation and Exploitations ratio

Mortality rates for both sexes were calculated in all lakes. Total mortalities (Z) calculated by catch curves are shown in Figure 3. Length-converted catch curves was in lakes Manyas, Ulubat, and İznik as Z= 1.87, (female), Z= 1.52, (male), Z= 1.78, (female), Z= 1.69, (male), and Z= 1.79, (female), Z=1.78, (male), respectively. Natural mortality were estimated as M= 0.81, (female), M= 0.70, (male), M= 0.65, (female), M= 0.68, (male), and M= 0.60, (female), M=0.85, (male), respectively. The exploitation ratio was obtained from total mortality and natural mortality in lakes Manyas, Ulubat, and İznik as E= 0.57, (female), Z= 0.54, (male), Z= 0.63, (female), Z= 0.57, (male), and Z= 0.66, (female), Z=0.53, (male), respectively.

Discussion

Although numerous studies have been carried out on morphological and biological traits of *A. leptodactylus*, no study of this species was found on population structure, growth parameters, natural and fishing mortality in the area of northern part of Turkey. There are seasonal fluctuations in abundance in the *A. leptodactylus* population in three different lakes with a peak abundance in September and October. Maximum abundances in all years studied were coincided with the maximum water temperature, which is similar to the observations of Berber and Mazlum (2009). The size structure of the population abundance indicates as three age groups, with the first group constituting the greatest proportion of the population. This suggests that the study area plays an important role in a larval abundance of the crayfish. But overall abundance of *A. leptodactylus* is very low during the study period. This study indicated one major recruitment event per year. This is the same as the previous studies which suggest breeding once a year (Köksal, 1988). Mature *A. leptodactylus* reproduces only once a year in natural conditions (Reynolds et al., 1992). We observed no evidence to suggest the occurrence of multiple spawning during this study. In addition, *A. leptodactylus* have low fecundity and long embryonic development (6-9 months) in natural conditions (Reynolds et al. 1992), but females can spawn every year. According to Köksal (1988), males and females of *A. leptodactylus* reach sexual maturity in third year at a body length of about 78-82 mm. In the present study, we found that the size

Table 3. Female age groups mean length for *A. leptodactylus* in three lakes.

Months	Ages	Fishing Lakes											
	Groups	Manyas				Ulubat				İznik			
April 02	1	55.5	3.6	5	n.a.	41.82	4.64	161	n.a.				
	2	63.76	2.59	7	2.67	57.02	3.56	28	3.71				
May.02	1	47.81	3.16	11	n.a.	44.02	2.32	8	n.a.				
	2	57.81	1.75	7	4.07	52.32	0.77	8	5.37				
	3					61.5	3.6	5	4.2				
June 02	1	56.13	3.71	36	n.a.	41.93	2.96	37	n.a.	45	3.3	29	n.a.
	2	64.5	4.36	11	2.07	53.04	2.32	10	4.21	52.5	4.03	5	2.05
	3					61.58	2.59	3	3.48				
July 02	1	45.98	2.32	24	n.a.	46.04	3	16	n.a.	43.6	2.94	62	n.a.
	2					52.11	2.73	21	2.12				
	3					64.5	2.66	4	4.6				
Agust 02	1	45.73	3.17	10	n.a.	43.5	3.6	9	n.a.	42.6	3.03	9	n.a.
	2					49.5	2.26	10	2.05				
Sep.02	1	50.5	2.08	7	n.a.	38.58	2.68	39	n.a.	46.7	2.02	50	n.a.
	2					50.1	2.8	12	4.2				
	3					55.5	3.22	9	1.79				
Oct.02	1	36	4.26	33	n.a.	37.46	3.75	42	n.a.	52.4	3.91	39	n.a.
	2	53.61	2.86	13	4.95	45.28	1.4	22	3.04	64.5	3.53	3	3.25
	3					55.5	3.6	3	4.09				
Nov. 02	1	35.9	2.84	22	n.a.	46.5	3.6	15	n.a.	41.7	3.11	26	n.a.
	2	58.5	4.71	5	5.99								
Dec.02	1	31.09	3.58	27	n.a.	31.5	4.71	5	n.a.	41.7	3.11	40	n.a.
	2	38.28	3.57	42	2.01	37.5	9.71	11	0.83				
	3	53.51	2.07	7	5.4								
Jan. 03	1	36.48	4.69	20	n.a.	33.13	7.05	27	n.a.	41.4	2.64	18	n.a.
	2	53.57	3.98	9	3.94	46.5	2.57	8	2.78				
	3	64.5	8.83	4	1.71								
Feb. 03	1	37.5	3.5	28	n.a.	31.5	3.6	3	n.a.	46.5	2.86	4	n.a.
	2	56.81	1.97	18	7.06	44.26	1.43	10	5.07	53.6	1.77	10	3.08
Mar.03	1	37.5	3.6	5	n.a.	40.5	3.86	21	n.a.				
	2	56.5	5.1	5	4.37	52.78	2.52	3	3.85				
	3					59.5	2.34	6	2.77				

Table 4. Male age groups mean length for *A. leptodactylus* in three lakes.

Months	Ages Groups	Fishing Lakes											
		Manyas				Ulubat				İznik			
April 02	1	41.1	2.8	12	n.a.	37.28	2.07	28	n.a.	41.31	2.45	12	n.a.
	2	49.5	1.41	3	3.99	46.99	4.07	73	3.16	51.62	1.18	20	5.68
May.02	1					38.5	2.08	7	n.a.	42	2.55	4	n.a.
	2					61.5	2.86	4	9.31	52.92	3.6	18	3.55
June 02	1					43.5	3.6	3	n.a.	42.66	2.07	32	n.a.
	2					53.02	2.61	13	3.07	47.14	4.05	24	1.46
	3					58.5	2.71	11	2.06	55.5	3.32	10	2.27
	4					73.5	2.02	10	6.34				
July 02	1	40.5	7.03	11	n.a.	45.62	3.03	9	n.a.	34.5	3.6	5	n.a.
	2	56.9	1.83	7	3.7	53.95	3.87	28	2.41	43.97	2.99	84	2.87
	3	66.93	2.34	4	4.81	61.05	3.58	15	1.91				
	4					73.5	2.02	10	4.45				
Agust 02	1	40.5	5.17	12	n.a.	43.5	4.71	5	n.a.	43.5	4.92	40	n.a.
	2	53.93	2.68	9	3.42	56.91	4.35	19	2.96				
Sep.02	1	40.5	5.17	12	n.a.	37.7	3.46	79	n.a.	46.75	2.34	31	n.a.
	2	53.93	2.68	9	3.42	63.99	3.61	9	7.44				
Oct.02	1	40.5	2.92	66	n.a.	40.2	3.06	60	n.a.	39	3.33	7	n.a.
	2	51.98	1.53	4	5.16	52.5	2.62	2	4.33	51.96	1.85	14	5
	3	61.5	3.12	7	4.09					64.5	3.6	9	4.6
Nov. 02	1	39.17	2.48	31	n.a.	42.24	3.43	72	n.a.	41.93	4.09	34	n.a.
	2					52.5	2.56	8	3.43				
	3					64.5	2.53	5	4.72				
Dec.02	1	40.09	3.31	196	n.a.	42	3.35	220	n.a.	40.26	2.76	31	n.a.
	2					63.24	4.05	8	5.74	55.5	30.1	2	0.93

at maturity of females of *A. leptodactylus* varied among the investigated lakes. The differences in the size at maturity form the different lakes could be attributed to different growth, since sizes at maturity may be under control of many factors, such as water temperature, water quality, food supply, and crayfish density (Westman et al., 1995). Therefore, the slower growth and smaller maturity size of crayfish in the three lakes may be more likely due to other factors, e.g., the increase in crayfish density, the removal of the largest crayfish from the lakes, and predatory hunting.

A. leptodactylus is active and feeds during the day and night (Mackeviciene, 1999). Possibly, since it spends more time for feeding, it can grow faster. The crayfish from the Lake Iznik had the longest CL but was not different from the values obtained from the other lakes. Predators hunting during the day are common in all three lakes, and the macrophytes in Manyas Lake provide better protection from the predators than Lake Ulubat and Iznik, neither of which has sufficient water plants but only rocks to give shelter. In addition, water visibility is rather poor in summer in Manyas Lake, which is another protection option from the predators.

The use of von Bertalanffy growth models is consistent with many studies on crustacean growth (Campbell, 1983; Pauly et al., 1984; Roa and Ernst, 1996; Alves and Pezzuto, 1998). The growth parameters (L_∞ and K) for the three lakes were different. The longer life span may be partially due to a lack of fishing mortality, especially on older crayfish. There are only minor differences in the growth performance indices among the three lakes. It is normally assumed in growth models that growth in carapace length is similar for both sexes. Our

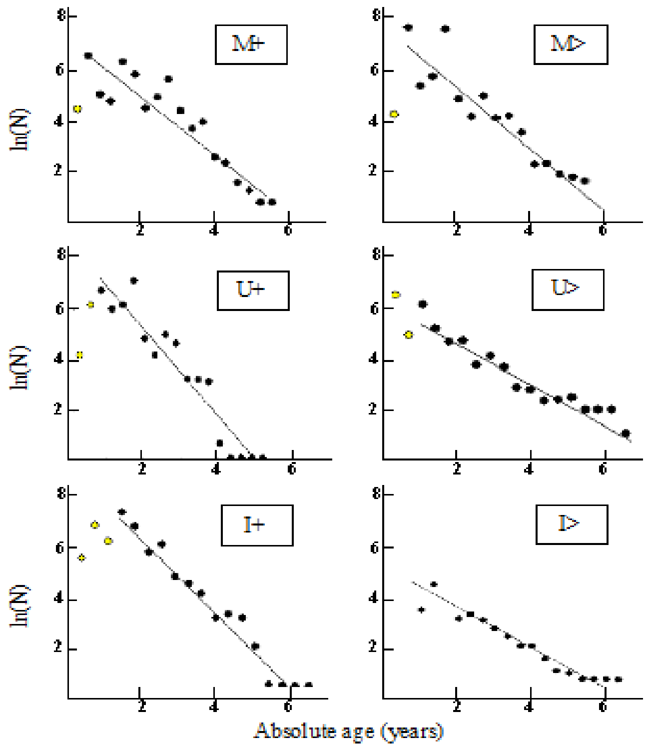

Figure 3. Seasonalized length-converted catch curve for *A. leptodactylus*

results indicated that females grew faster and reached a larger size at the same age than males, with slow growth in both sexes during the winter.

Fishing pressure had different effects on sexes in these lakes. In addition in Manyas Lake fishing activity was being limited by Turkish government at the time of study (Anonymous, 2002). For this reason in Manyas Lake fishing pressure could be different than the other lakes. Unlike the other two lakes females stock seems to be vulnerable to pressure according to von Bertalanfy parameters and mortality rates. On the other hand, male stocks seem to be vulnerable to the same causes in Ulubat Lake and İznik Lake. From this point of view we can say that there are more fishing pressure on males which are relatively more active than females throughout the season. However, when the fishing pressure was over, males must have had an adverse effect on female stocks. Slowing down of growth in females coincides with the maturation and spawning period, reflecting metabolic costs associated with reproductive activities plus a cessation of molting during the spawning period. The faster growth of females is in contrast to many other crustacean species where the males have the faster growth due to the reduction in female growth rate associated with egg production and egg incubation (Hartnoll, 2001). Increase in weight, as well as in length, are estimations used to evaluate growth. Both measures are practical and have provided valuable information, especially in fields like aquaculture, where economic interest is centered on global production as a result of the increase in biomass and survival in a given time (Barbosa, 1998). Since crayfish are mainly exploited in traditional fisheries (Morrissy, 1983; Huner, 1994), it is necessary and urgent to manage crayfish using statistical models. This also provides great support in decision making with respect to choosing and implementing sustainable fisheries. According to (Deval et al., 2007) the graph corresponding to the growth obtained using the equations calculated with the von Bertalanffy model, these crayfish present a slow rate of growth (0.025 cm/day) compared with other crustaceans like *Penaeus vannamei* (0.10 cm/day). This is very probably due to the drastic environmental variations that can be present in their habitat, such as pollution, dissection, little food and low temperatures, factors that not only modify the rate of growth, but affect the speed of the physiological processes. Therefore the physiology of the organisms as well as their population dynamics are directly affected by the conditions prevailing in the environment, which on some occasions provoke stress and mortality (Hartnoll, 1982). During the first intervals of time, the increases in length are a little larger in comparison with others but decrease with age. Size is a factor that is inversely related to age, that is, the smallest organisms exhibit higher growth rates. In the first stages of development, most of the energy is channeled into growth. As the organisms reach maturity, part of the energy is channeled to the development of the reproductive apparatus, and once in maturity, when definitive size has been reached, energy is basically destined to the production of gametes (Barbosa, 1994).

Data from Lake Iznik, Lake Manyas and Lake Ulubat comply with the general linear pattern for composite data and specific cases of lakes but the existence of various models is not so apparent. We have, in fact, data from these lakes for only 2002-2003 periods. These lakes had an expanding population of crayfish that appeared until 20 years when an *A. astaci* plague epidemic destroyed a formerly thriving commercial fishing. We don't have much information on what has happened in the mean time. It may represent a relatively young population that could be expected to continue to survive and to grow in significant numbers to sizes over 9 cm. Conversely, it could be relatively an old population on being of a potentially significant mortality. The carapace length frequency graph for males fits the general high mortality pattern more than the one for females. This is due, in part, to sale of males larger than 9 cm prior to our access to samples, but it must be emphasized that absolute numbers of legal size crayfish was not high. However it might be due to intensive fishing pressure on male sizes.

Larger sizes of crayfish compared with other populations can be explained by the fact that the crayfish were caught with standard commercial nets, which have a larger mesh than our test nets and those used by the fisherman in these lakes. An argument that this would lead to stock collapse appears groundless because all females would have spawn youngster before becoming vulnerable to the fishery. Survival of those young would have increased rather than decrease as a consequence of reduction of predation pressure by larger males.

Another reason for the decline in population might have been due to larger and older crayfish which displayed an aggressive behavior toward smaller individuals. This may have resulted in cannibalism. Manyas Lake may in part suffered from have been the result of cannibalism. Since most males completed their molt before the female molt began, an opportunity for cannibalism existed. Although males may very likely eat females that are molting, there is little likelihood that females substantially prey on males, because females must have started their migration to deeper water by the time the second male molt is under way.

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